FINAL

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT FOR THE VASQUEZ BOULEVARD AND INTERSTATE 70 SITE, OPERABLE UNIT 2 DENVER, COLORADO

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LIST OF ACRONYMS AND ABBREVIATIONS

CCOD	City and County of Denver
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CDPHE	Colorado Department of Public Health and Environment
CDOT	Colorado Department of Transportation
COPC	Chemical of Potential Concern
EPC	Exposure Point Concentration
HQ	Hazard Quotient
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
LOEC	Lowest Observed Effect Concentration
NAWQC	National Ambient Water Quality Criteria
NPL	National Priority List
OERR	Office of Emergency and Remedial Response
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PEC	Probable Effect Level
RAGS	Risk Assessment Guidance for Superfund
SQG	Sediment Quality Guidelines
TAL	Target Analyte List
TEC	Threshold Effect Concentration
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
VBI70	Vasquez Boulevard and Interstate 70
XRF	X-Ray Fluorescence

1.0 INTRODUCTION

1.1 Purpose of this Document

This document is a screening level ecological risk assessment for Operable Unit 2 of the Vasquez Boulevard and Interstate 70 (VBI70) Site in Denver, Colorado. Operable Unit 2 focuses on the area of the site formerly occupied by the Omaha & Grant Smelter. The purpose of the document is to assess the potential risks to ecological receptors, both now and in the future, from site-related contaminants present in environmental media, assuming that no steps are taken to remediate the environment or to reduce contact with contaminated environmental media.

The results of this assessment are intended to help inform risk managers and the public about potential ecological risks attributable to site-related contaminants and to help determine if there is a need for action at the site. The overall management goal is to ensure protection from deleterious effects of acute and chronic exposures to site-related chemicals for both current and future land uses.

The methods used to evaluate risks in this assessment are consistent with current USEPA guidelines for ecological risk assessment (USEPA 1992a; 1997; 1998) provided by the USEPA for use at Superfund sites.

1.2 Overview of the Eight-Step Ecological Risk Assessment Process

The United States Environmental Protection Agency (USEPA) has developed methods and procedures for completing ecological risk assessments at hazardous waste facilities (USEPA 1992a; 1998). Figure 1-1 shows an eight-step process that is recommended for ecological risk assessments completed at Superfund sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (USEPA 1997). It is important to realize that the eight steps shown in Figure 1-1 are not intended to represent a linear sequence of mandatory tasks. Rather, some tasks may proceed in parallel, some tasks may be performed in a phased or iterative fashion, and some tasks may be judged to be unnecessary at certain sites.

1.3 Purpose of the Screening-Level Ecological Risk Assessment (Steps 1 and 2)

This document is intended to fulfill Steps 1 and 2 of the ecological risk assessment process presented in Figure 1-1. These steps are intentionally simplified and conservative, and usually tend to overestimate the amount of potential risk. Thus, any exposure scenario or chemical that is not identified as being of potential concern in the initial screen may be eliminated from further consideration, allowing subsequent efforts to focus on factors that may be of concern. The results of the screening level assessment are also used to identify the specific types of data needed to complete a more detailed assessment. The screening level assessment is not intended to support any final quantitative conclusions about the probability or magnitude of potential ecological risks.

1.4 Organization of this Document

In addition to this introduction, this report is organized into the following sections:

Section 2 — This section provides a description of the site and a review of data that characterize the nature and extent of environmental contamination at the site.

Section 3 — This section identifies ecological exposure scenarios of potential concern at the site. The screening-level problem formulation is also presented, including the Site conceptual model, identification of pathways and receptors of potential concern, and the identification of assessment and measurement endpoints.

Section 4 — This section provides a summary of the screening-level methods used in this risk assessment.

Section 5 — This section presents the screening-level risk evaluation for plants and soil invertebrates. This section includes a summary of the exposure assessment, toxicity assessment, risk characterization and uncertainties.

Section 6 — This section presents the screening-level risk evaluation for aquatic receptors. This section includes a summary of the exposure assessment, toxicity assessment, risk characterization and uncertainties.

Section 7 — This section provides citations for all data, methods, studies, and reports utilized in this risk assessment.

2.0 SITE CHARACTERIZATION

2.1 Site Description

The Vasquez Boulevard/Interstate 70 (VBI70) Superfund Site is located in the north-central portion of Denver, Colorado, near the intersection of Interstate 70 and Vasquez Boulevard. Three major smelters have operated in the vicinity of the VBI70 site, including the Argo Smelter, the Omaha and Grant Smelter, and the ASARCO Globe Smelter (Figure 2-1). The VBI70 site consists of three Operable Units (OUs):

- Operable Unit 1 (OU1) - Off-facility (non-smelter) soils (residential soils)
- Operable Unit 2 (OU2) - Omaha and Grant Smelter on-facility soils
- Operable Unit 3 (OU3) - Argo Smelter on-facility soils

This document is an assessment of the potential for exposure and risk to ecological receptors due to releases from the former Omaha and Grant Smelter site, designated as Operable Unit 2 (OU2) of the VBI70 Superfund Site.

2.1.1 Location

The VBI70 OU2 site is located on 67 acres of land within the City and County of Denver, Colorado, at approximately the intersection of 42nd Avenue and Vincent Street. Figure 2-2 shows the property previously occupied by the Omaha and Grant Smelter which is bounded by the following:

- Northwest – Colorado and Eastern Railroad (Burlington Northern Santa Fe railroad)
- Northeast – Union Pacific Railroad
- Southwest – 39th Avenue
- Southeast – Brighton Boulevard (formerly Wewatta Street)

2.1.2 Land Use

Land Use at the VBI70 OU2 Site

The historical land use at the VBI70 OU2 site was primarily industrial and included smelting (1883 – 1903) and municipal waste incineration (1933-1945) (EnviroGroup 2001). The location of the historical smelter facilities are presented in Figure 2-3.

The current land use at the VBI70 OU2 site is primarily commercial/industrial, with recreational use at a small portion of the site located immediately adjacent to the South Platte River at the Globeville Landing Park. The ground is largely covered by highways, building structures, and paved parking lots. Grassy or unpaved areas are rare and are mainly restricted to the western most portion of the site at the Globeville Landing Park and some small areas at some of the commercial properties along Brighton Boulevard and 39th Avenue on the eastern and southern portions of the site.

The potential future land use of the VBI70 OU2 site is multi-family residential, with the approximate size of the multi-family units ranging from 5 to 20 acres (EMS Inc., 2008).

In this risk assessment, the area located within the National Priorities List (NPL) site boundary (see Figure 2-2) is considered "on-site".

Surrounding Land Use

The land use surrounding the VBI70 OU2 site is mainly commercial/industrial, interspersed with private residences, and with recreational land use along the South Platte River (EnviroGroup, 2001; CDPHE 1992).

In this risk assessment, the area located outside of the NPL site boundary (see Figure 2-2) is considered "off-site".

2.1.3 Topography

The VBI70 OU2 Site is located on the east bank of the South Platte River. The topography of the site varies from approximately 5195 feet above mean sea level along the eastern boundary of the site to approximately 5137 feet along the South Platte River. The general drainage pattern is from the southeast toward the northwest toward the South Platte River. The South Platte River floodplain in the vicinity of the site is approximately 300 feet wide and approximately 9 feet lower than ground elevations along the east bank of the river (EnviroGroup, 2001).

The site topography has been altered by fills and excavations over the 100-years of activity at the site. All smelter features, such as slag piles and buildings have been removed although buried building debris and facility foundations may still exist at VBI70 OU2 below modern day facilities and paved areas (EnviroGroup, 2001).

2.1.4 Geology and Hydrogeology

Detailed information on the geology and hydrogeology in the area of the site is described in Robson and Romero (1981), Robson (1996), the preliminary assessment for the site (CDPHE, 1992), and in the Draft Facility Conceptual Model for the site (EnviroGroup, 2001). Information from these sources that is helpful in performing an evaluation of potential human health and ecological risks at the site is summarized below.

Geology

The VBI70 OU2 site is located east of the Front Range of the southern Rocky Mountains. The sedimentary rocks underlying the region are known as the Denver Basin, an asymmetric, north-south trending structural basin. The uppermost bedrock formation below the site is the Denver Formation, consisting of inter-bedded claystone and shale (typically about 70%), and siltstone with silty sandstone lenses (typically about 30%) (CDPHE, 1992). The approximate depth to the eroded bedrock surface in the vicinity of the VBI70 OU2 site ranges from 35 feet to 45 feet below ground surface (EnviroGroup, 2001).

Unconsolidated sediments, comprised of alluvium, colluvium, and eolian deposits overlie most of the bedrock in the Denver area. The thickness of the unconsolidated sediments is generally less than 20 feet. However, there are some areas within the Denver Basin where the thickness of unconsolidated sediments exceeds 80 - 100 feet (Robson, 1996). Broadway Alluvium and younger Post-Piney Creek Alluvium and artificial fill (including smelter slag) overlie the claystone at the VBI70 OU2 site.

Hydrogeology

There are two primary groundwater systems underlying the site: an upper shallow alluvial system and a deeper bedrock aquifer (the Denver Aquifer). The two systems are separated by more than 70 feet of low permeability claystone. The depth to groundwater in the shallow alluvial system usually ranges from about 10-20 feet below the ground surface. The shallow alluvial system is comprised of sand and gravel that contains various amounts of clay and silt. In some areas these coarse grained materials grade to a fine material, with clay and silty materials predominating. Due to the higher hydraulic conductivity of the weathered bedrock than the underlying unweathered bedrock, groundwater preferentially flows horizontally in the alluvial/weathered unit rather than downward towards the deep bedrock aquifer (CDPHE, 1992). Regionally, the direction of groundwater flow in the upper alluvial system is to the northwest toward the South Platte River (EnviroGroup 2001).

2.1.5 Basis for Concern

Smelter operations are often associated with the generation and release of various types of metal-containing waste materials, including slag. Environmental media which may be impacted by environmental releases include surface soil, subsurface soil, and groundwater. Most metals in smelter wastes can cause adverse effects in ecological receptors if contamination and exposure levels are high enough.

The potential sources of chief concern at the former Omaha & Grant Smelter are historic smelting-related solid wastes, potentially including slag, stack emissions, and other solid and liquid wastes generated and disposed of on the site. Such wastes and contamination may exist both in current surface soils (that which exists immediately below current paved areas at the site) as well as in buried subsurface deposits. Contaminants leaching from surface and subsurface sources may also migrate into the groundwater (CDPHE 1992).

2.2 Site Investigations

Several investigations have collected samples of soil, groundwater, surface water and/or sediment at or in the vicinity of the VBI70 OU2 site. The available data for each media are briefly described below and are summarized in Tables 2-1 through 2-2.

2.2.1 Soil Data

VBI70 OU2 Remedial Investigation

2004 - 2005

Both surface and sub-surface soil samples were collected at the site in support of the remedial investigation at VBI70 OU2. A total of 25 surface soil samples (0-2") were collected from areas of currently exposed soil at the site. A total of 41 subsurface soil samples were collected from 10 borings (7 soil borings and 3 monitoring well borings) located in areas of the site that were most likely to have been impacted by historic operations, releases, and on-site disposal (EnviroGroup 2004). Grab samples were collected from the top 6-8" of each sub-surface soil horizon at depths up to 20 feet below ground surface. Both surface and sub-surface soil samples were analyzed for total arsenic, cadmium, lead and zinc. These four analytes were retained for analysis based on the results of previous investigations at the other two operable units at VBI70 and based on the results of previous investigations at the nearby Globe Plant site. Sample locations are shown in Figure 2-4 (see "BH Soil Samples", "MW Holes", "XXXX Brighton Blvd" and "4600 Humbolt Blvd" sample locations) (EnviroGroup 2004).

2008

In December 2008, CCOD collected additional surface soil and subsurface soil samples from the VBI70 OU2 site in support of the remedial investigation/feasibility study and risk assessment at the site. A total of 14 surface soil samples and 33 subsurface soil samples were collected from 14 stations, shown in Figure 2-4 (see "2008 Drilling" locations). Samples were analyzed for total lead and arsenic. These two chemicals were identified as the chemicals of potential concern at the site, based on a review of the historical soil samples collected at the site and the draft risk assessment report (USEPA 2006) that was prepared for the VBI70 OU2 site (EMS Inc. 2008).

Surface soil samples were collected from the top one foot of soil (0-1 foot). In cases where the soil was bare, the sample depth is 0-1 foot below ground surface (0 – 1 foot bgs). In cases where the soil was covered by pavement, it is anticipated thickness of pavement and base course is approximately 1 foot so the top foot of soil is anticipated to occur at a depth of 1-2 feet bgs or 0-1 feet below pavement surface (0 – foot bps). The entire one foot sample was homogenized and submitted for analysis for lead and arsenic by ICP-MS (method 6020B).

Subsurface samples consisted of composite samples collected over 5 foot depth intervals (e.g., 0-4 feet, 4-9 feet, and 9-14 feet). Sub-samples were collected from each 1 foot portion of the 5 foot core and were combined, homogenized and submitted for analysis lead and arsenic by ICP-MS (method 6020B).

Brighton Boulevard Phase II Targeted Brownfield Site Assessment

During April-May of 2003 and January of 2004, sub-surface soil samples were collected at and adjacent to the VBI70 OU2 site as part of the Phase II Environmental Site Assessment of the Brighton Boulevard brownfield site (URS 2004). As part of this investigation, a total of 6 sub-surface soil samples were collected from the southeast edge of the VBI70 OU2 site, along Brighton Boulevard. Borings were advanced until groundwater or refusal. Composite samples were collected over the top coring interval (0-3' or 0-4' below ground surface) and analyzed for the 23 Target Analyte List (TAL) metals. Sample Locations that are considered on-site for the VBI70 OU2 risk assessment are shown in Figure 2-4 (see "BB-BB-XX" samples).

City and County of Denver Coliseum Barn Soil Excavations

In October 2003, surface soil and sub-surface soil samples were collected at the VBI70 OU2 site during excavation activity at the Coliseum Barn (located on the west side of the Coliseum proper) to support the structural reinforcement of the barn roof (CH2MHill 2004). A total of 2 surface soil samples and 5 sub-surface soil samples were collected. Surface soil samples were composite from soil surrounding the excavation areas. Four sub-surface samples were collected from excavations at the four corners of the barn structure. Samples were composite over a depth of 0-5 feet below ground surface. Additionally, 1 sub-surface grab sample was collected from one excavation that appeared to be the most contaminated. Soil samples were analyzed for RCRA metals using EPA Method 6020A. Sample Locations are shown in Figure 2-4 (see "Barn Samples").

Globeville Landing Park Soil Sampling

In July of 2002, sub-surface soil samples were collected from the Globeville Landing Park to characterize arsenic and lead concentrations in soil for workers who may be exposed during maintenance activities (CH2MHill, 2002). A total of 64 sub-surface soil samples were collected from 32 locations at depths of 0-2 and 2-3 feet below ground surface. At 3 locations, additional subsurface samples were collected at depths of 4-6 feet below ground surface. Composite samples were collected over the sampling depth interval and analyzed for arsenic and lead. Sample locations are presented in Figure 2-4 (see "SB Soil Samples").

Pepsi Bottling Group Soil Testing for Lead and Arsenic

During the period of August 2001 through January 2002, Pepsi Bottling Group collected samples of soils disturbed during construction activities at 7 areas of its facility located at the VBI70 OU2 site (Transportation Industrial Services Inc., 2001a through 2002). During these investigations, 10 sub-surface soil samples were collected from 5 on-site locations. Sub-surface samples were composite over 2 depths (0-10 and 10-20 feet below ground surface) at each sample location and analyzed for lead and arsenic. Most of these sample locations are shown in Figure 2-4. Most of these sample locations are shown in Figure 2-4 (see "Pepsi Area X Soil Samples" and "Pepsi UT (Utility Trenches) Soil Locations").

Colorado Department of Transportation

As part of planning modifications to Interstate 70 (I-70), the Colorado Department of Transportation (CDOT) conducted site investigations (Walsh 1991 and 1997) along I-70, at and in the vicinity of the northern boundary of the VBI70 OU2 site. During these investigations, a total of 6 sub-surface soil samples were collected at 6 on-site locations. Sub-surface soil samples were composite over the borehole depth, which ranged from 11.5 to 22 feet below ground surface. Samples were analyzed for 16 metals (As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, V, Zn). Sample locations are presented in Figure 2-4 (see "CDOT Holes").

2.2.2 Surface Water and Sediment Data

VBI70 OU2 Remedial Investigation

Data collection for the Remedial Investigation (EnviroGroup 2004) also included the collection of paired surface water and sediment data from 2 locations in the South Platte River shown in Figure 2-5. The stations sampled were positioned upgradient (station N43) and downgradient (station N46) of the site to evaluate any impacts to the South Platte River from groundwater discharging from the site. Surface water samples were analyzed for total and dissolved metals (As, Cd, Cu, Pb, Zn) and sediment samples were analyzed for total metals (As, Cd, Cu, Pb, Zn). Additional surface water samples were collected monthly from the downgradient station (N46) for part of 2005 (EnviroGroup 2004).

2.3 Data Evaluation

2.3.1 Data Usability for Risk Assessment

Soil

All soil data described above were reviewed to determine their suitability for use in risk assessment, with two exceptions. The soil data collected at the Globeville Landing Park were excluded from the risk evaluation because USEPA has removed this property from the VBI70 OU2 Superfund Site study area (USEPA 2003a). Additionally, soil samples collected at depths greater than 10 feet were excluded from the risk assessment. The anticipated depth of excavations for basements for a hypothetical future development is expected to be 10 feet or less (EMS Inc. 2008). Thus, disturbances where subsurface soil could be brought to the surface and spread around where ecological receptors may become exposed is not likely to occur for subsurface soils located at depths greater than 10 feet.

The soil data were also reviewed to assess the usability of the data in risk assessment. Although complete laboratory data packages were not available for review, because the data were collected in accordance with documented plans and/or procedures and for the most part using EPA-approved analytical methods, all soil data were determined to be acceptable for use in the RI and risk assessment (EMS Inc., 2008).

Surface Water and Sediment

The surface water and sediment data were also reviewed to determine their suitability for use in risk assessment. Because the surface water and sediment data were collected in accordance with documented plans and/or procedures approved by EPA, all soil data were determined to be acceptable for use in the risk assessment.

All data used in the risk assessment are provided electronically in Appendix A.

2.3.2 Summary Statistics

Summary statistics for the concentrations of metals in site media are presented in Tables 2-3 through 2-4.

In site soil, several metals, including those typically associated with mining-related activities (arsenic, cadmium, copper, lead and zinc), were frequently detected. Arsenic and lead were present at very high levels in some sub-surface samples, with maximum concentrations of 950 mg/kg and 3,600 mg/kg, respectively.

In surface water and sediment, metals were frequently detected in samples collected from both upgradient and downgradient stations. Concentrations in surface water and sediment in upgradient stations were generally similar to those observed at downgradient stations, with one exception. Concentrations of lead in sediment tended to be higher at the upgradient station than those observed in samples collected from the downgradient station.

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3.0 SCREENING-LEVEL PROBLEM FORMULATION

Exposure is the process by which ecological receptors come into contact with chemicals in the environment. In general, receptors can be exposed to chemicals in a variety of environmental media (e.g., soil, water, air, food), and these exposures can occur through several pathways (e.g., ingestion, dermal contact, inhalation). Section 3.1 identifies ecological receptors that may be exposed to site-related contaminants and the exposure pathways that might result in these receptors coming into contact with site-related contaminants. Section 3.2 provides an evaluation of exposure pathways that could lead to contact with site-related contaminants at this site and identifies the pathways that are believed to be the most significant at the site. Section 3.3 describes the management goals for ecological receptors at the site. Section 3.4 describes the quantifiable assessment endpoints used to evaluate attainment of the management goals for ecological receptors.

3.1 SITE CONCEPTUAL MODEL

Figures 3-1 presents the site conceptual model showing how chemicals that may have been released from the former Omaha & Grant Smelter might result in exposure of ecological receptors.

3.1.1 Exposure of Ecological Receptors

As seen in Figure 3-1, the ecological receptors most likely to be exposed to site-related contaminants now and in the future are urban wildlife (sparrows, squirrels, mice, etc), plants, and aquatic receptors (fish and benthic macroinvertebrates) in the South Platte River. Each of these populations is briefly described below.

Urban Wildlife

Based on the highly urban and industrialized nature of the site, the only wildlife species expected to occur are those adapted to an urban setting, such as sparrows, squirrels, and mice. These wildlife species may ingest or have direct contact with surface soil, surface water, and sediment at the site. Wildlife may also have exposure to subsurface soils, if in the future construction or redevelopment activities result in subsurface soils being brought to the surface and left uncovered.

Plants

Although most of the site is paved or covered with buildings, in the future, landowners may wish to develop landscaped areas to allow plant growth (grass, shrubs, trees, etc), where plants may be exposed to contaminants in surface soil. Exposure to subsurface soil that is brought to the surface during construction/development activities may also occur in the future.

Aquatic Receptors

Groundwater flowing from the site may recharge in the South Platte River where aquatic receptors, such as fish and benthic macroinvertebrates, may have direct contact with contaminants in surface water and sediment.

3.2 POTENTIAL PATHWAYS AND RECEPTORS OF CONCERN

As noted above, ecological receptors could be exposed to site-related contaminants by several pathways. However, not all of these exposure routes are likely to be of equal concern. Exposure scenarios that are considered to be potentially significant are shown in Figure 3-1 by boxes containing a solid black circle. Pathways that are judged to contribute only occasional or minor exposures are shown by boxes with an "X". Incomplete pathways (i.e., those which are not thought to occur) are shown by open boxes. The following sections provide the basis for identifying the relative significance of these pathways.

3.2.1 Ecological Exposure Pathways

Wildlife Exposures

Based on the highly urban and industrialized nature of the site, the only wildlife species expected to occur are those adapted to an urban setting (e.g., sparrows, squirrels, mice, etc). However, because nearly the entire site is covered with pavement or buildings, there is very little usable habitat or food supply available, even for urban wildlife. Consequently, risks to wildlife at the site are considered to be negligible and are not evaluated in this assessment.

Phytotoxicity

Similarly, because most of the site is paved or covered with buildings, there is no significant plant growth at the site and there is no current basis for concern over phytotoxicity. However, some property owners might, in the future, wish to develop landscaped areas to allow plant growth (grass, shrubs, trees, etc), so exposures of plants to contaminants in surface soil is of potential concern in the future and is evaluated quantitatively in this assessment.

Exposure of Aquatic Receptors

Direct Contact with Surface Water and Sediment

There are no permanent surface water bodies on site, so exposure of aquatic receptors is not of concern at on-site locations. Exposure of off-site aquatic receptors could be of potential concern if contaminated groundwater from the site discharges into the South Platte River where aquatic receptors may have direct contact with these chemicals. Thus, these pathways will be evaluated quantitatively by the risk assessment.

Ingestion of Surface Water and Sediment

Ingestion of surface water and sediment is a pathway of potential concern for aquatic receptors. Quantitative evaluation of oral exposure for aquatic receptors is limited by lack of oral toxicity values for aquatic receptors, so ingestion exposures are evaluated qualitatively rather than quantitatively for these receptors.

3.2.2 Summary of Pathways of Principal Concern

Based on the evaluations above, the following pathways are judged to be of sufficient potential concern to warrant quantitative risk evaluation:

Exposure Medium	Exposed Receptors	Exposure Route
Soil (surface and subsurface)	Current/future plants	Direct contact
Surface Water	Aquatic receptors	Direct contact
Sediment	Aquatic receptors	Direct contact

3.3 MANAGEMENT GOALS

Management goals are descriptions of the basic objectives which the risk manager at a site wishes to achieve. The overall management goal identified for ecological health at the VBI70 OU2 Superfund Site is as follows:

> *Ensure adequate protection of ecological systems and receptor populations within and in the vicinity of the Site by protecting them from the deleterious effects of acute and chronic exposures to Site -related contaminants.*

"Adequate protection" is generally defined as protection of growth, reproduction, and survival of local populations. That is, the focus is on ensuring sustainability of the local population, rather than on protection of every individual in the population.

3.4 ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment Endpoints

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. In accord with the general management goals identified above, the assessment endpoints selected for this Site are:

- Adequate protection of aquatic receptors from adverse effects related to exposure to chemicals in surface water and sediment.

- Adequate protection of terrestrial plants and terrestrial soil invertebrates from adverse effects related to exposure to chemicals in surface and subsurface soil.

Measurement Endpoints

Measurement endpoints represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (USEPA, 1992a; 1997). In general, there are three basic categories of measurement endpoints that are useful in evaluating the assessment endpoints at a site:

- <u>Predicted Risks</u>, based on a comparison of measured concentrations of contaminants in site media to levels that are believed to be safe.
- <u>Site-specific toxicity studies</u> where test organisms (fish, invertebrates, plants, etc) are exposed to site media.
- <u>Site-specific surveys</u> of ecological receptor density and diversity, and comparison to a suitable reference area.

In general, each of these categories of measurement endpoint has some advantages and some limitations, so the most reliable risk assessments utilize information from all three types of endpoint and use a weight of evidence approach. However, because screening level ecological risk assessments are typically performed at an early stage of a site investigation, the measurement endpoints used in screening level assessments are generally restricted to the risk prediction approach. The screening-level measurement endpoints for each assessment endpoint are summarized in Table 3-1.

4.0 SCREENING LEVEL APPROACH

As described previously, the USEPA has established an eight step process (see Figure 1-1) for conducting ecological risk assessments at Superfund sites (USEPA, 1997). In accord with this guidance, the SLERA for the VBI70 OU2 Superfund Site represents the first two steps in the 8-step process.

The screening level approach depends on the predictive approach, often referred to as the Hazard Quotient (HQ) approach. In this approach, the estimated exposure from a site is compared to a "benchmark" or value that is believed to be without significant risk of unacceptable adverse effect:

$$HQ = (\text{Concentration}) / (\text{Benchmark})$$

If the HQ does not exceed 1.0, then it is concluded that risks are below a level of concern. If the HQ exceeds 1.0, then risks or the potential for adverse effects may be of concern, and additional evaluation may be warranted. Note that an HQ that exceeds 1.0 is not equal to certainty of adverse effects.

HQ values are calculated using conservative exposure assumptions. The results are intended to provide an initial characterization of potential risks to various classes of ecological receptors, to identify those chemicals and exposure pathways associated with potential risks, and to identify any data gaps which may need to be addressed to support a baseline risk assessment. As above, an HQ greater than 1 in the refined screen is not proof of an adverse effect, but is an indication that additional evaluation in the baseline assessment is warranted.

This approach is discussed in greater detail for each receptor group in Section 6 (Screening-Level Evaluation for Plants) and Section 7 (Screening-Level Evaluation for Aquatic Receptors).

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5.0 SCREENING-LEVEL EVALUATION FOR PLANTS

This section provides a screening-level evaluation of risks to terrestrial plants living in soils which are potentially impacted by contaminants from the VBI70 OU2 site.

5.1 Exposure Assessment

Chemicals of Potential Concern

A formal selection of chemicals of potential concern (COPCs) to terrestrial plants in soil was not conducted. Instead, risks were conservatively evaluated from all chemicals for which data were available. Table 5-1 presents the chemicals measured in soil that were retained for quantitative evaluation of potential risks to terrestrial plants in the screening level ecological risk assessment.

Exposure Points

Because the concentration of metals in soil varies from location to location, and because plants are not mobile, each soil sample was evaluated as an individual exposure point. Risks were evaluated not only for the surface layer, but also for samples from deeper depths (up to 10 feet) in order to evaluate risks if the subsurface soil were brought to the surface in the future. As described Section 2.3.1, the soil data set used in the risk assessment include surface and subsurface soil sample collected at depths of 10 feet or less.

Exposure Point Concentrations

The exposure point concentration (EPC) used to evaluate risks to terrestrial plants was simply the concentration of a metal in a sample, or if a chemical was not detected than the ½ of the detection limit was used as the EPC. Rejected (R-qualified) data were not used when calculating an EPC.

Appendix C summarizes the EPCs for each chemical in soil that was used to evaluate potential risks to terrestrial plants.

5.2 Toxicity Assessment

Toxicity benchmark values for the protection of terrestrial plants from contaminants in soils were selected from two different sources: EPA’s Eco-SSLs and Oak Ridge National Laboratory (ORNL) soil TRVs. When an appropriate toxicity value was provided in each source, Eco-SSL values were preferred to ORNL values. Table 5-2 summarizes the selected toxicity benchmarks for plants used to estimate risks from soil.

Ecological Soil Screening Levels (Eco-SSLs)

The Eco-SSL derivation process represents a three year collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry, and academic participants led by the USEPA, Office of Emergency and Remedial Response (OERR) (USEPA 2003b). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern in soils which require further evaluation. Eco-SSLs were derived separately for four groups of ecological receptors, plants, soil invertebrates, birds, and mammals. For the purposes of this risk assessment, the plant-specific Eco-SSL was used to estimate risks.

Oak Ridge National Laboratory (ORNL)

ORNL reviewed data on the toxicity of contaminants in soil on a wide range of plant species and determined the lowest observed effect concentration (LOEC) (Efroymson et al. 1997). The LOEC is defined as the lowest applied concentration of the chemical causing a greater than 20% reduction in the measured response. The LOECs for a series of different plants species were then rank ordered and a benchmark value was selected that approximated the 10th percentile of the distribution of LOECs. When a toxicity benchmark was based on a lethality endpoint, the benchmark value was divided by 5 to approximate an effects concentration for growth and reproduction. The benchmark values were then rounded to one significant figure.

5.3 Results

Table 5-3 presents the estimated HQ values for plants exposed to chemicals in soil samples collected at the site. For reference, HQ values based on the average soil concentration measured by the U.S. Geological Service (Shacklette and Boerngen 1984) in Colorado counties near the site (Arapahoe, Douglas, Jefferson) are also shown. In interpreting the HQ values, it is helpful to consider not only the value of the HQ from the site samples, but also the value of the site samples compared to the HQ value reference soils (state background). If the HQ values for reference soils (state background) are greater than 1, it is considered likely that the TRV for that chemical may be overly conservative for use at this site, since risks to plants are not expected in background soils. When this occurs, it is probably because the TRV is based on studies in which readily soluble forms of the metal were added to bulk soil, and hence the TRV may not account for cases where metals in site soils exist is poorly soluble (low bioavailability) mineralogical forms.

Based on this approach, inspection of Table 5-3 reveals the following main points:

- Estimated HQs for barium, chromium, manganese and vanadium exceed 1 for the reference soil. This indicates that the toxicity benchmarks for these chemicals may be overprotective for this site, and hence HQ values greater than 1 for these chemicals in site samples should be interpreted as uncertain.

- For chemicals where the background HQ does not exceed 1 (antimony, arsenic, beryllium, cobalt, copper, lead, mercury, nickel, selenium), most HQ values for site soils are below 1 in both surface and subsurface soils, but there are scattered samples with HQ values above 1. The frequency of these samples is summarized in Table 5-4. As seen, most exceedences are relatively small (HQ = 1-2), although some larger exceedences are observed (especially for arsenic, lead and zinc).

- The largest exceedences (HQ > 10) tend to occur at depth in subsurface soils beneath the Pepsi Plant Property, Coliseum Barn and commercial properties along Brighton Boulevard the vicinity of Station BH-06.

- A few surface soil locations at commercial properties on Brighton Boulevard have moderate exceedences (HQ = 2-5 and HQ = 5-10) due to concentrations of arsenic and zinc, whereas, many surface soil locations at commercial properties on Brighton Boulevard, the Pepsi Plant and on CCOD property (4600 Humbolt samples) have moderate exceedences due to concentrations of lead.

These calculations indicate that levels of arsenic and lead and perhaps a few other metals in soils from areas within the former smelter area and known slag deposits may be within range of potential phytotoxicity in some locations. Because most of the locations that are of potential concern are in subsurface soils, these predicted risks are not currently of concern, but could be of concern if soils became exposed and subsurface materials were brought to the surface. However, there are a few locations where concentrations of arsenic and lead in surface soil could currently be phytotoxic to plants. Because of the uncertainty in most plant TRVs for metals, further testing would be needed to confirm these predictions.

5.4 Uncertainties

Uncertainties in Soil Benchmarks

The toxicity benchmarks used in HQ calculations for plants are usually based on laboratory studies in which soluble forms of test metals are added to test soils. Thus, these values do not account for occurrence of metals in mineral forms that are largely insoluble and do not contribute as much toxicity as soluble forms. In addition, the values do not account for variations in soil factors such as pH and total organic carbon content which may influence the toxicity of metals in soils to terrestrial plants. Finally, the laboratory toxicity tests may not utilize species that are likely to occur in Site soils. Based on these considerations, confidence in the soil benchmark values and hence confidence in the HQ values is low.

Uncertainties from Chemicals without Soil Benchmarks

Soil benchmark values were not available for six chemicals (aluminum, calcium, iron, manganese, potassium and sodium). The majority of chemicals without benchmarks are considered essential nutrients and are required by plants for normal functioning. Nevertheless, elevated levels of these chemicals could be toxic to both plants. The absence of soil benchmarks for these chemicals could result in an underestimate of risk.

6.0 SCREENING-LEVEL EVALUATION FOR AQUATIC RECEPTORS

This section provides a screening-level evaluation of risks to aquatic receptors in the South Platte River that are exposed to surface water and sediment that have been potentially impacted by contaminants from the VBI70 OU2 site.

6.1 Exposure Assessment

Chemicals of Potential Concern

A formal selection of chemicals of potential concern (COPCs) to aquatic receptors in surface water and sediment was not conducted. Instead, potential risks were conservatively evaluated from all four chemicals for which data were available (arsenic, cadmium, lead and zinc).

Exposure Points

Because the concentrations of metals in surface water and sediment may vary between upgradient and downgradient locations in the river, and because each station represents a location where aquatic receptors could be exposed, each sample station was treated as an individual exposure point.

Exposure Point Concentrations

Because of the assumption of random exposure over an exposure area, risk from a chemical is related to the arithmetic mean concentration of that chemical averaged over the entire exposure area. Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, the USEPA recommends that the upper 95th percentile confidence limit (UCL) of the arithmetic mean at each exposure point be used when calculating exposure and risk at that location (USEPA 1992b). If the 95% UCL exceeds the highest detected concentration, the highest detected value is used instead (USEPA 1989).

The approach that is most appropriate for computing the 95% UCL of a data set depends on a number of factors, including the number of data points available, the shape of the distribution of the values, and the degree of censoring (USEPA 2002a). At this site, when 10 or more samples were available for a chemical, the EPC was calculated using EPA's ProUCL Software (USEPA 2007). If less than 4 samples were available, the maximum concentration was used as the EPC. Samples that are below the detection limit were evaluated using a value equal to one-half the detection limit. Rejected (R-qualified) data were not used when calculating an EPC.

Appendix C presents tables that summarize the EPCs for surface water and sediment used to estimate potential risks to aquatic receptors.

6.2 Toxicity Assessment

6.2.1 Toxicity Reference Values for Surface Water

Toxicity reference values used to evaluate risks to aquatic life (fish, benthic macroinvertebrates) from contaminants in surface water were the USEPA National Ambient Water Quality Criteria (NAWQC) (USEPA 2002b). These values are summarized in Table 6-1 and are briefly described below. The acute NAWQC is intended to protect against short-term (48 to 96 hour) lethality, while the chronic NAWQC is intended to protect against long-term effects on growth, reproduction, and survival. The NAWQC values are not species-specific, but are designed to protect 95% of the aquatic species for which toxicity data are available (USEPA 1985).

6.2.2 Toxicity Reference Values for Sediment

Toxicity reference values used to evaluate risks to aquatic life (fish, benthic macroinvertebrates) from contaminants in sediment were the Consensus-Based Sediment Quality Guidelines (MacDonald et al. 2000). These values are summarized in Table 6-1.

For each chemical of concern, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified based on available sediment toxicity literature. The consensus-based TECs were calculated by determining the geometric mean of all threshold effect values from the literature. The consensus-based PECs were calculated by determining the geometric mean of all probable effect values from the literature. A summary of the types of sediment effect concentrations included in the TEC and PEC calculations is provided in MacDonald et al. (2000). The lowest benchmark value (TEC or PEC) for a chemical was used to estimate risks to aquatic receptors from contaminants in sediment.

6.3 Results

Surface Water

Table 6-2 presents the estimated risks to aquatic receptors (benthic organisms, fish, amphibians) from exposure to metals in the South Platte River. As seen, risks at both the reference and downstream location are below a level of concern (HQ < 1E+00) for all chemicals. This indicates that any impacts of groundwater discharging from the site to the South Platte River are not of ecological concern.

Sediment

Table 6-3 summarizes the estimated risks to benthic organisms from exposure to metals in sediments in the South Platte River. Both the absolute risks (risks from the total concentration of metals measured in sediment) and the site-related incremental risk (downstream risk – upstream risk) are presented. As seen, risks at both the reference and downstream location are below a level of concern (HQ < 1E+00) for all chemicals, with the exception of lead in sediment at the upstream (N43) location. Because this one exceedence is upgradient of the site, this also indicates that any impacts of groundwater discharging from the site and potentially impacting sediments in the South Platte River are not of ecological concern to benthic organisms in sediment.

6.4 Uncertainties

Uncertainties in Chemicals Not Evaluated

Risks were quantified only for chemicals for which data were available in surface water and sediment (arsenic, cadmium, lead and zinc). This omission may tend to underestimate total risk

Uncertainties in Exposure Point Concentrations

In all exposure calculations, the desired input parameter is the true mean concentration of a contaminant within a medium, averaged over the area where random exposure occurs. However, because the true mean cannot be calculated based on a limited set of measurements, the USEPA (1989, 1992b) recommends that the exposure estimate be based on the 95% upper confidence limit (UCL) of the mean. When data are plentiful and inter sample variability is not large, the EPC may be only slightly higher than the mean of the data. However, when data are sparse or are highly variable, the EPC may be far greater than the mean of the available data. Such EPCs (substantially higher than the sample mean) reflect the substantial uncertainty that exists when data are sparse or highly variable, and in general are likely to result in an overestimate of risk.

At this site, the EPC was the 95th UCL or the maximum concentration. The 95th UCL was calculated when 4 or more sample results were available for a chemical. In cases where less than 4 sample results were available, the maximum concentration was used as the EPC. The data sets for surface water, sediment, groundwater and soil were somewhat limited, and the maximum concentration was often used as the EPC at the majority of these exposure units. In cases where the inter sample variability is small, this is not likely to overestimate the mean concentration and risk estimates. However, in cases where the data are highly variable the maximum could result in an overestimate of risk. Overall, uncertainties in exposure point concentrations are more likely to overestimate than underestimate risks.

Uncertainties in Toxicity Benchmark Values

Sediment

Sediment toxicity benchmarks for benthic invertebrates used in the screening level evaluation are based on studies in which multiple contaminants were present and assumes all of the observed toxicity was due to the contaminant of interest, even though other contaminants in the sediment may be associated with observed toxicity. Therefore, there is uncertainty that exceedence of the benchmark for a particular chemical will actually cause toxicity in benthic organisms. In addition, there may be a wide variety of differences between sediments in the South Platte River and the sediments used to establish the toxicity benchmarks, which could influence the relative toxicity of chemicals in the sediments. Because of these limitations in bulk sediment benchmarks, HQ values based on the benchmarks should be considered uncertain, and more likely to overestimate than underestimate risks.

Surface Water

Benchmark values used to predict risk to aquatic receptors from contaminants in surface water are based on National Ambient Water Quality Criteria or Great Lakes Tier II values. These benchmarks are based on a multiple toxicity studies and are intended to be protective of most aquatic species for which reliable toxicity data are available. However, the set of organisms for which there are data may not include the organisms most likely to be present in the site and reference waters. In addition, these benchmarks are based on studies performed in laboratory waters, and may not account for site-specific factors that influence toxicity of metals. Because of this, risk predictions based on these benchmarks may either overestimate or underestimate risks to site species.

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